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(54) **WIDE FIELD OF VIEW (WFOV) OPTICAL SYSTEM AND METHOD**

(71) Applicant: **KOPIN CORPORATION**, Westborough, MA (US)

(72) Inventors: **Rodney Bumgardner**, Beaverton, OR (US); **Raymond T. Hebert**, Florence, OR (US)

(73) Assignee: **KOPIN CORPORATION**, Westborough, MA (US)

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,212,209 A 7/1980 Newbold
5,151,823 A 9/1992 Chen
(Continued)

Primary Examiner — Balram T Parbadia
(74) *Attorney, Agent, or Firm* — Peloquin, PLLC; Mark S. Peloquin, Esq.

(57) **ABSTRACT**

Systems and methods are described for a wide field of view (WFOV) optical doublet system. The system includes a first lens. The first lens has a first surface facing a viewer side of the system and a second surface facing away from the viewer side. The first lens has a positive refractive power. The system includes a second lens. The second lens has a first surface facing the first lens and a second surface facing away from the first lens. The second lens has a positive refractive power. The system includes a display panel. The display panel has a display surface facing the second surface of the second lens. The first lens, the second lens, and the display panel are configured in order from the viewer side along an optical axis of the system. Only one surface of either the first lens or the second lens is a diffractive surface and only two surfaces are Fresnel surfaces. In operation, light from an image displayed on the display surface enters the system through the second surface of the second lens and is magnified and presented in a system exit pupil. The system exit pupil is on the viewer side and a field of view presented to the viewer is at least eighty (80) degrees.

19 Claims, 13 Drawing Sheets